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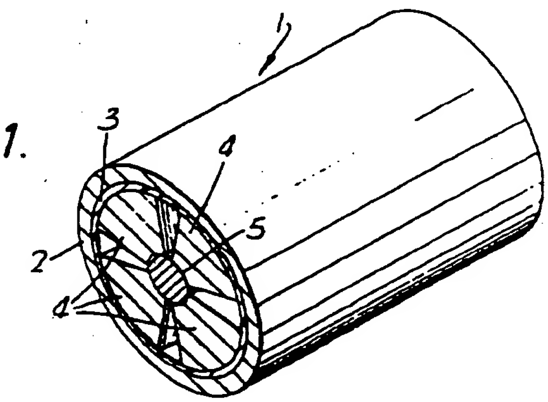
F16L

(54) **Repeater housing**

(57) An electrically-insulating liner tube (3) is inserted into a repeater housing (seacase)(2) with interference fit by a method involving the use of a vacuum applied to the inside of an oversize liner tube whereby to reduce the outside diameter thereof of a value at which it may simply be slid into the housing. Subsequent to the insertion in the housing the vacuum is removed and the liner tube's outside diameter permitted to increase. The liner tube (11) is preferably drawn down by the vacuum onto an apertured mandrel tube (7—Fig. 2, 14—Fig. 3) and inserted into the housing together with the mandrel tube, which is removed allowing removal of the vacuum. Such an inserted liner tube is required for submarine optical repeaters (regenerators) (1) where the electronic components must be electrically insulated from the repeater housing (seacase) but with a continuous heat conduction path therebetween to ensure regen rator reliability.

Fig.1.



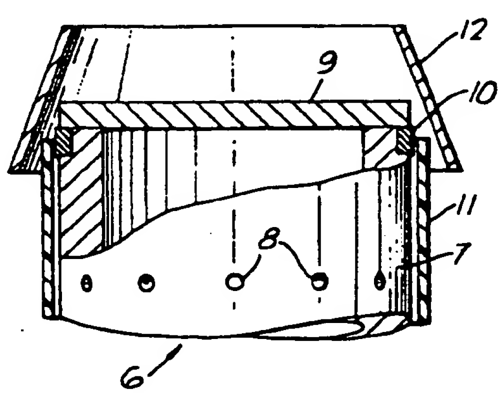


Fig. 2.

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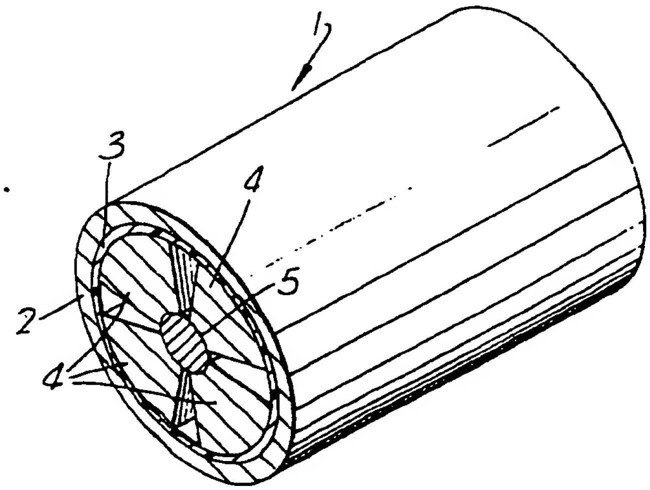
Fig. 1.



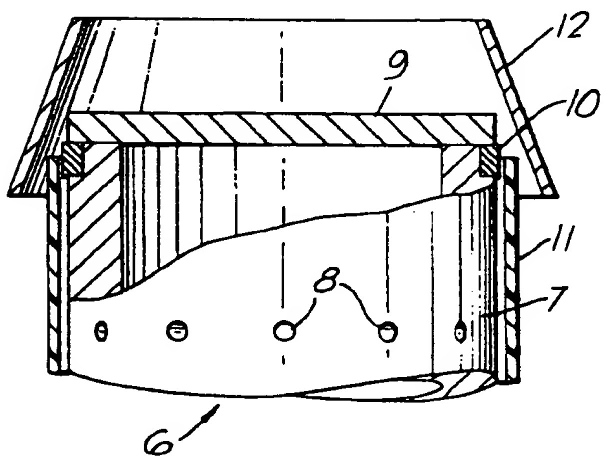


Fig. 2.

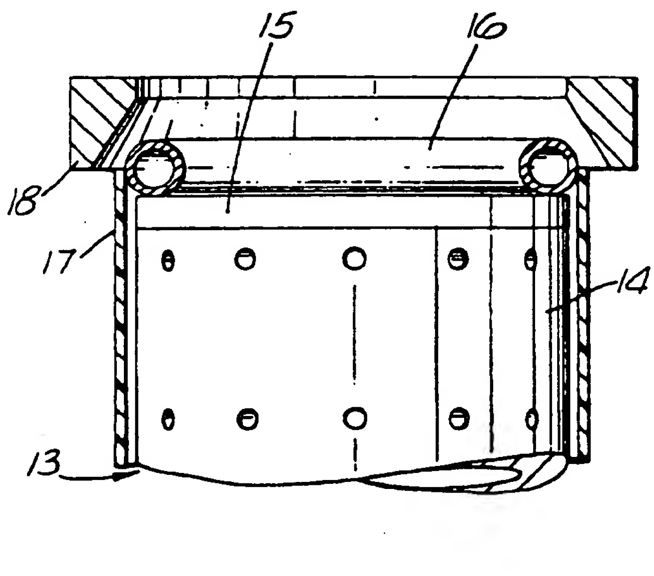


Fig. 3.

SPECIFICATION

Repeater housing

This invention relates to a repeater housing and in particular to repeater housings for submarine optical communications cables and to their manufacture.

Submarine cable repeater housings (seacases) are manufactured of high strength metals in order to withstand sea bottom pressure, cable laying and recovery. High voltages are employed to power the electronic circuits within the repeater and it is necessary to electrically insulate these electronic circuits from the seacase which is at sea ground potential. The thermal management of optical cable repeaters (regenerators) requires a continuous solid conduction path from the electronic regenerator components to the environment external to the repeater seacase. The optical cable regenerator components generate more heat than those for analogue cables and in order to ensure long term reliability of the repeaters for optical cables the heat transfer must be carefully managed. It is not sufficient to rely on convection.

In US patent specification 4528615 there is described a repeater housing and circuit mounting structure which addresses this problem. In order to electrically isolate the electronics from the seacase a layer of an electrical insulator is applied to the inside surface of the seacase. A suitable insulator being a mica-filled epoxy which is applied as a paste uniformally to the inside surface of the seacase to a thickness suitable to withstand the expected high voltage and to maximise heat transfer through it. The electronic components are mounted on structures designed as heat sinks and which will act as heat conduits to the layer of insulation. When inserted in the seacase contoured surfaces of the mounting structures fit snugly against the layer of insulation whereby to facilitate heat transfer from the components to the seacase.

It has previously been proposed to employ seacase liners comprising thin-walled extruded polyethylene tubes for electrical insulation purposes in analogue repeaters. However these are only a loose fit within the seacase and will not provide the necessary continuous solid heat conduction path from the regenerator components of optical cable repeaters to the seacase.

The present invention has as an object to provide an electrical insulation layer within a seacase by an alternativ method t that discl sed in US 4528615 but which also ensures the requisite solid heat conduction path is provided.

According to on aspect of the pr sent invention there is pr vided a method of inserting a liner into a housing comprising the steps by applying a vacuum to the interior thereof, inserting the reduced outside dimensions liner into said housing, and removing the vacuum whereby to allow the outside dimensions of the liner tube to increase.

According to a further aspect of the present invention there is provided apparatus for use in inserting a liner into a housing comprising means for reducing the outside dimensions of the liner, by applying a vacuum to the interior of the liner, and for maintaining the reduced outside dimensions of the liner tube until the liner has been inserted in the housing.

Embodiments of the invention will now be described with reference to the accompanying drawings, in which

Fig. 1 shows schematically a view of a seacase with an insulating liner and a structure therein on which the regenerator electronic components are mounted and which is in suitable thermal contact with the liner for use as an optical repeater;

Fig. 2 shows schematically and partially in cross-section one arrangement for vacuum shrinking a liner tube onto a mandrel, and

Fig. 3 shows schematically and partially in cross-section an alternative arrangement for vacuum shrinking a liner tube onto a mandrel.

Referring firstly to Fig. 1, there is indicated schematically a repeater (regenerator) 1 comprising a metallic seacase 2, an electrically-insulating liner 3 and four elements 4 comprising a structure on which the regenerator electronic components (not shown) are mounted. These four elements 4 may be of such dimensions as to be inserted loosely into the lined seacase and then caused to adopt the required thermal contact position relative to the liner 3 by urging them radially outwards by, for example, the insertion of a central member 5. Alternatively the elements may be spring loaded relative to one another in order to achieve the required thermal contact position. There are many possibilities for the electronic component mounting structure, however, since this does not form part of the present invention it will not be discussed in greater detail. The repeater will also be provided with glanding arrangements etc (not shown) at its ends for the entry of the cable ends thereto.

The present invention is concerned with providing an electrically insulating liner within a seacase in such a manner that optimum thermal contact between electronic elements within the liner and the seacase itself can be achieved.

As previously mentioned it is known to use a thin walled plastics, for example polyethylene tub , as an electrically insulating liner, however, these were previously only a loos fit within the seacase. It will be appreciated that whilst it is easy to insert an undersize liner tube into a seacase mer ly by sliding it in, it is not so easy to insert into a seacase a

good thermal contact, since for that purpose the outer diameter of the liner tube should be at least equal to the internal diameter of the seacase, and preferably there should be a diametric interference fit therebetween.

The method of inserting such a liner tube into a seacase in order to obtain an interference fit proposed by the method of the present invention is based on temporarily shrinking an oversize liner tube onto a mandrel of suitable dimensions, inserting the mandrel with the shrunk liner tube thereon into the seacase, allowing the liner tube to regain its original dimensions whereby it adopts an interference fit with the seacase and removing the mandrel. The mandrel is a tube with apertures in its wall and the liner tube is shrunk onto the mandrel by evacuating the tube, suitable seals being provided at the ends of the liner tube to enable the shrinking to be achieved.

One possible arrangement for vacuum shrinking a liner tube onto a mandrel is shown in Fig. 2. A mandrel 6 comprising a tube 7 with apertures 8 is completely closed at one end by an end plate 9 whereas the other end (not shown) is suitable for connecting to a vacuum pump, for example, for evacuation purposes. Adjacent the end of the tube 7 is an annular seal member 10, for example of closed cell foam rubber, which will provide a working seal when the tube is evacuated and a seacase liner 11 has been shrunk onto the mandrel tube 7. In order to provide an initial vacuum seal, that is in order that when the vacuum is first applied to the mandrel it can be effective to begin to pull the liner tube down onto the tube, a rubber boot 12 is provided into which the mandrel and seacase liner are inserted until there is sealing contact therebetween sufficient for the vacuum to have the desired effect on the seacase liner tube. As will be appreciated a seal member 10 and a rubber boot 12 will be required at both ends of the tube 7.

Another possible arrangement for vacuum shrinking a liner tube onto a mandrel is shown in Fig. 3. In this case the mandrel 13 is also an apertured tube 14 closed at one end by an end plate 15 and provided with a suitable arrangement at the other end for connection to a vacuum pump (not shown). In order to provide an initial seal and a working seal a rubber tube ring seal 16 is disposed at the end of the mandrel 13 and the end of a seacase liner 17. An internally tapered element 18 is employed to hold the seal 16 and liner 17 tog ther for the initial vacuum seal and in use of the arrangement will be di posed s ated in the seal 16 rather than spaced apart therefr m as indicated in the drawing. As will be appreciated a similar sealing arrangement is provided adjacent the other end of the mandrel 13.

is, with the initial vacuum seals provided by suitable contact between the various elements, a vacuum is applied to the interior of the mandrel tube and the liner is pulled down onto the mandrel. With the vacuum maintained the rubber boots, as in the Fig. 2 arrangement, or the elements 18, as in the Fig. 3 arrangement, are removed and the liner and mandrel inserted into the appropriate position in a seacase, the vacuum is removed and the liner then expands into engagement, with an interference, with the internal wall of the seacase.

The above-described methods of fitting a liner tube into a seacase thus may be considered as resulting from causing the temporary reduction of the diameter of the liner by the elastic strain due to the hoopstress in the liner caused by evacuation of the tube of the mandrel. Since the liner tube is initially oversize a ridge will tend to form in the liner tube parallel to the axis of the mandrel when the latter is evacuated but such a ridge will either disappear with time and is temperature dependent or can be eased out by kneading. The modulus of elasticity of the liner tube material varies with temperature and in some situations the vacuum pull-down of the liner tube may be advantageously carried out at temperatures higher than room temperature to reduce the incidence or magnitude of such buckling ridges. A factor affecting buckling is the material of the mandrel and in particular the coefficient of friction of the mandrel material. To compensate for the effect of friction the modulus of elasticity needs to be reduced, and this is achieved by the aforementioned heating. Alternatively the mandrel may be coated with a low coefficient of friction material e.g. PTFE in which case no heating is necessary.

CLAIMS

1. A method of inserting a liner into a housing comprising the steps of reducing the outside dimensions of the liner by applying a vacuum to the interior thereof, inserting the reduced outside dimensions liner into said housing, and removing the vacuum whereby to allow the outside dimensions of the liner tube to increase.

2. A method as claimed in claim 1 wherein the housing comprises a repeater housing, the liner is a liner tube, the outside dimension being the diameter thereof, and wherein the outside diameter of the liner tube before reduction is such that the inserted liner tube is an interference fit in the repeat r housing.

3. A method as claimed in claim 2, wherein t reduce the outside diameter f the liner tube a mandrel tube with an apertured wall is disposed within the liner tube, wherein vacuum seals ar provided between the liner tube ends and the mandrel tube, wherein the vacuum is applied to the interior of the man-

together with the liner tube th reon is inserted into the housing and following removal of the vacuum the mandrel tube is removed from the liner tube.

4. A method as claimed in claim 3 wherein the vacuum seals each comprise means providing an initial vacuum seal and means providing a working vacuum seal.

5. A method as claimed in claim 4 wherein the working vacuum seal comprises an annular seal disposed at the respective mandrel tube end and engaged by the liner tube in the pulled-down state thereof.

6. A method as claimed in claim 5, wherein the initial vacuum seal is formed by engaging a rubber boot with the respective mandrel tube end and the respective liner tube end, which rubber boots are removed prior to inserting the mandrel tube with the liner tube thereon into the housing.

7. A method as claimed in claim 4 wherein the initial and working seals are provided by an annular tubular seal disposed at the mandrel tube end and engaged by the liner tube in the initial and pulled-down state thereof, means being provided to hold the tubular seal and liner tube together for the initial vacuum seal, which means are removed prior to inserting the mandrel tube with the liner tube thereon into the housing.

8. A method as claimed in any one of claims 3 to 7 wherein the mandrel tube is coated on its outer tubular surface with a material having a low coefficient of friction.

9. A method as claimed in claim 8, wherein said material is PTFE.

10. A method as claimed in any one of the preceding claims wherein the liner is a thin-walled polyethylene tube.

11. A method of inserting an electrically-insulating liner tube with an interference fit into a repeater housing substantially as herein described with reference to Fig. 2 or Fig. 3 of the accompanying drawings.

12. Apparatus for use in inserting a liner into a housing comprising means for reducing the outside dimensions of the liner, by applying a vacuum to the interior of the liner, and for maintaining the reduced outside dimensions of the liner tube until the liner has been inserted in the housing.

13. Apparatus as claimed in claim 12 and comprising a mandrel tube with a smaller outside diameter than the inside diameter of the liner which is a tube and with an apertured wall, means for releasibly sealing the ends of the liner tube to the ends of the mandrel tube and means for applying a vacuum to the interior of the mandrel tube, whereby to pull the liner tube d wn onto the mandrel.

14. Apparatus for use in inserting a liner tube into a repeater housing substantially as herein described with reference to Fig. 2 or Fig. 3 of the accompanying drawings.

15. A repeater housing having an electrically insulating liner tube ins rted therein with an interference fit by a method as claimed in any one of claims 1 to 11.

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